THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT

Economic Impact of Mining through Linkages: A Case Study of 1980 and 2014 Production Linkages in Zimbabwe

Lyman Mlambo
Chairman, Institute of Mining Research, University of Zimbabwe, Zimbabwe
Isaac Kwesu
Chief Executive Officer, Chamber of Mines of Zimbabwe, Zimbabwe

Abstract:
The manner in which mining is linked to other sectors of the economy in production, the extent of those linkages, and the problems and constraints which limit the development of production linkages are critical questions in the context of optimizing the sector's contribution to economic development in Zimbabwe. The primary objective of this study is to examine the extent of the production (upstream and downstream) linkages that the mining sector has created with the rest of the Zimbabwean economic sectors, their effect on the wider economy and how these linkages may be optimized. A mixed methodology is used comprising a quantitative analysis using the Leontief Input-Output model and secondary data to quantify the linkages for 1980, and a partial survey of mines and exploration companies. The results of the survey are used to update the key quantitative results to 2014 and to further explore qualitatively the nature of production linkages, and constraints and problems limiting their development. The study finds that downstream linkages were weak. There was insignificant beneficiation of minerals or other value-adding activities due to several constraints, among them, lack of support infrastructure and technical expertise, and huge financial requirements. Failure to maximize production of 'development minerals' was a contributory factor to low downstream linkages. Slightly significant direct and total upstream linkages existed with manufacturing, electricityand water, and transport and distribution sectors. The mining sector's gross output multiplier was below but moderately comparable to those of other mining developing countries such as Chile. Upstream linkages were mainly constrained by lack of technical expertise and finance. Thus, overall production linkages were found to be weak. The paper makes several recommendations, among them, infrastructural development, increased primary production (for feed and market), larger expenditure on HRD and R&D, greater focus on development minerals and emphasis on incentives rather than penalties.

Keywords: Mining, production linkages, multiplier, downstream, upstream, beneficiation

1. Introduction

As African Union (2009) intimates, Africa's industrial development should be underpinned by the exploitation of its significant resource base. While richness and/or diversity in natural resources can be a springboard for economic development and industrialization, however, this result does not always follow. Torvik (2009) alludes to the paradox of plenty, in which the most fascinating part is the variation in development among resource-plenty countries, rather than the average impact of natural resource use. The question of the extent to which natural resources, especially minerals, can contribute to the economic development of Africa or developing countries in general, continues to dominate policy debate in these countries.

Zimbabwe has more than sixty different types of minerals and, historically, has exploited about forty of them (Mugandani & Masiya, 2011). Government perception is that the mining sector has not been contributing enough to the fiscus and to economic development of the country in general; a view that is disputed by the Chamber of Mines of Zimbabwe (2013) from a statistical standpoint. In 2015, the sector contributed 9% to nominal Gross Domestic Product (GDP), over 50% of total fixed capital formation, 65% of private sector investment, 11% of government fiscal receipts, 55% of total export value and 35,000 formal direct jobs, 70,000 indirect jobs through upstream and downstream industries (Mlambo, 2016), besides the various corporate social investments (Chamber of Mines of Zimbabwe, 2013). The Chamber further argues that the contribution to GDP would be higher if the multiplier effect of mining linkages and the induced effect of incomes generated from the mining sector were to be taken into account.

The manner in which mining in Zimbabwe is linked to other sectors of the economy, the extent of those linkages, and the problems and constraints which limit the development of linkages are important issues for discussion. Optimization of mining linkages would enhance the contribution of the mining sector to broad-based (balanced) economic growth and development in Zimbabwe. The premise for the latter is that, the mining sector is one of the growing sectors in Zimbabwe (Mlambo, 2016) and can contribute predominantly to economic recovery if it is better integrated into the country's industrialisation impetus (African Union, 2009). The World Bank (2014)notes that mining growth is autonomous, being essentially anchored by strong external demand.

2. Problem Statement and Objectives of the Study

The contribution of the mining sector to the Zimbabwean economy has mainly been perceived directly, through statistical contributions to macroeconomic indicators. A direct conception of mining contribution to the country's output as measured by the Gross Domestic Product is severely limited since it regards the mining sector in isolation. This is because such conception does not consider how the mining sector (or its multiplier effect) is integrated into the rest of the economy through production linkages, among other forms of mineral seminal economic linkages. Thus, the study is driven by the need to recognize, and determine the extent of, production linkages to the rest of the economy.

The primary objective of this study is to examine the extent of the production (upstream and downstream) linkages that the mining sector has created with the rest of the Zimbabwean economic sectors, their effect on the wider economy and how these linkages may be optimized. The specific objectives are to:

- Quantitatively determine the strength of the inter-industry dependence coefficients and therefore, Type I gross-output mining multipliers (sector-specific and economy-wide)[i]. Indicators are calculated for 1980, the year to which the latest Input-Output (I-O) data refers;
- Adjust the 1980 quantitative results obtained in (i), using: (a) results from a partial survey of mines and exploration companies carried out early 2014; and (b) intuitive deductions on the likely effect of economic changes over time (from 1980 to 2014) on typical assumptions of I-O models;
- Highlight constraints on development of the various mining linkages in Zimbabwe based on the 2014 survey of mines and exploration companies and recent literature on Zimbabwe; and
- Make recommendations on how mining linkages in Zimbabwe can be optimized.

The rest of the paper is organized as follows. The background section briefly highlights the country's mineral diversity and geological prospective, dearth of exploration, level of local mineral processing and beneficiation, mining fiscal regime, and recent trends in mining production in the country. This gives the context for the consideration of the extent and importance of production linkages to the economy. The literature review then defines the relevant concept of linkages and identifies different types of mining linkages. It also briefly explains the conceptual framework comprising the theoretical phases in the development of mining linkages and the I-O concept. It ends with a brief narration of results from studies in other countries.

The paper then gravitates into outlining the methodology. The quantitative part uses the input-output model to derive inter-industry dependence coefficients and gross-output mining multipliers for 1980. 1980 data is used because this is the latest Input-Output data available. This is followed by an adjustment of the major quantitative results for 1980 to the 2014 period. The qualitative analysis part presents and discusses qualitative aspects of the results from the survey of mines and exploration companies. This is followed by a discussion of factors constraining development of mining linkages. Recommendations on the way forward regarding optimization of mining linkages in Zimbabwe lead to the conclusions of the report.

3. Brief Background on the Mining Sector in Zimbabwe

Zimbabwe hosts more than 60 different types of minerals, of which 40 have been exploited to various extents at one point or another in the long history of mining in Zimbabwe, spanning more than 1000 years (Mugandani and Masiya, 2011; Roussos, 1988). Some of the major minerals among the 40 historically exploited include gold, platinum, diamonds, asbestos, nickel, coal, copper, chrome, iron, silver and cobalt. Table 1 shows estimated reserves and grades for some of these minerals as well as coal bed methane gas. For the latter, only preliminary exploration has been done.

Mineral	Estimated Potential Reserves (Ore)	Estimated Average Grade
Gold	84 million tons	4.9g/t
PGE[ii]	4.4 billion tons	3.6g/t, (4E)[iii]
Chromite	608 million tons	47%-60% chromic oxide
Nickel	114 million tons	0.87%
Coal	11 billion tons, 2.5 tons open-castable	13.50% ash content
Diamonds	38 million tons excluding Marange Fields	37.6 carats/100t
Copper	29.4 million tons	1.1% copper
Coal Bed Methane Gas	500 billion cubic metres, conservative estimate	95% purity

Table 1: Some of Zimbabwe's Estimated Potential Reserves (Ore)
Sources: IMR database and Mlambo (2010b)

While Zimbabwe has a clear diversity in minerals, that the country is mineral-rich is debatable given known information, except in few specific areas such as platinum and chromite. These two minerals (platinum and chromite) are hosted in the Great Dyke, a prominent geological feature of length 550km and width of between 3 and 11 km (Mlambo, 2010b). The Great Dyke runs roughly from the north-east to the south-west of the country. It also hosts other Platinum Group Metals (such as palladium, rhodium and ruthenium) and nickel. See map in Schlüter (2008).

Mugumbate (2010) bemoans the dearth of exploration in Zimbabwe, intimating that (for most of the minerals) there has been little exploration outside rediscovering deposits (among the more than 6,000) already known from ancient workings. Mining of most minerals has been by small-scale miners who lack both desire and capacity to undertake major exploration, even around their deposits. It has been surmised that a greater number of these small mines sit on expansive

deposits that need to be explored. Sanctions and the guerrilla war of the 1960s and 1970s, and the general and progressive disengagement from the international community since the late 1990s, have significantly affected exploration in Zimbabwe (Valliers, 1993; Mugumbate, 2010; Hawkins, 2009). This was especially the case during the former periods (1960s and 1970s), when new exploration methods and technologies were being developed and successfully applied elsewhere.

Most of the mineral products are destined for export markets, after undergoing basic processing (comminution and concentration) (see Platinum Producers Committee of the Chamber of Mines of Zimbabwe, 2012). Platinum Group Metals are currently processed to concentrate, and at best to matte; diamonds are marketed in their rough form; chrome is marketed as concentrate or ferrochrome; copper and nickel have been sold as cathode; gold is sold as bullion; iron is marketed as pig iron; and tantalite is sold as concentrate. There is, theoretically, great scope for value addition in all these examples and many others left out. For example, rough diamonds can be cut, polished and made into diamond jewellery; ferrochrome can be used in stainless steel production, *et cetera*. The Government, in 2015, imposeda 15% export tax on unrefined exports of platinum and chrome, in an effort to force local refinery; this has, however, been deferred to 1 January 2022(See also Mlambo, 2018b).

All minerals except gold and silver are marketed through the Minerals Marketing Corporation of Zimbabwe. All gold is sold to Fidelity Printers and Refineries which then refines it into gold bullion. A multiplicity of taxes, charges and fees constitutes the mining fiscal regime, major of which are royalties, corporate tax, PAYE, additional profit tax, VAT, capital gains tax, withholding tax, non-residents shareholder's tax, customs duties, marketing commission, licensing fees, environmental charges, local authority charges, *et cetera* (ZELA, 2012). Taxes and fees in 2013 constituted 17% of mining revenue and around 60% of the mining sector profitability (Chamber of Mines of Zimbabwe, 2013). As many as nine Acts govern the administration of tax in the mining sector (Mlambo, 2018a). The mining industry is concerned with the instability of the fiscal regime, especially the royalty rate,and its fragmented nature in the form of a multiplicity of tax heads and collecting agencies. Generally, concerns of mining revenue transparency abound, with respect to amounts received by mining companies, how much they pay to government, how much the government receives and how the government uses revenue from the mining sector (see Everret *et al*, 2014).

The state dilemma of control and capital in most mineral-rich developing countries (see Gocht *et al*, 1988) is also evident in Zimbabwe. It is characterized by two conflicting goals: (i) the desire to own and control exploitation of mineral resources and obtain the maximum benefits; and (ii) the imperative to have technical know-how and capital from industrialized countries. The first goal has resulted in a mining law that is essentially *regalian* as well as adoption of participation policies. This saw the government enacting an indigenization policy which prescribed majority government equity (51%) in all mining companies with a capital value of at least US$500,000, a policy which has now been reversed for all the minerals. Recently, it has seen government mulling introduction of production sharing agreements (PSAs) despite the fact that these are normally applied to the oil and gas sectors. It has, in the worst, created policy inconsistency.

From 2006 to 2011, the mining sector rose from 3.6% to 13% of GDP (Chamber of Mines of Zimbabwe, 2012). This was due to liberalization measures introduced in 2009 which restored confidence in the mining sector and resulted in previously closed mines being reopened, mainly in gold mining. Month-on-month and year-on-year output showed positive growth trends. The stability of the economic environment through multi-currency adoption also contributed to the growth. For example, the historical development of the gold sector from 1980 to 2014 generally manifests three phases: (i) increased growth from 1980 to 1999; (ii) falling trend from 2000 to 2008; and (iii) a general resurgence post 2008 to 2014 (Mlambo, 2018a).

4. Literature Review

4.1. Introduction

Mining linkages can be defined in different ways: quantitatively as inputs into and outputs from mining operations, or qualitatively in terms of the relationships between enterprises in the (mining) supply chain or even as the exchange of ideas (related to the mining sector operations) (African Union, 2009). In a business set-up, linkages are used to define any commercial interaction between different profit-oriented enterprises and can take many forms such as supply contracts, partnerships and joint ventures or more informally, sharing of market information or technologies.

Mining linkages are definitely a desirable phenomenon as there are many benefits that can be derived from them (Oyejide & Adewuji, 2011). Linkages can result in the 'deepening' of the resources sector as up-, down- and side-stream (infrastructure) industrial linkages could form core industrialisation nuclei for the economy and could, over time, diversify with increasing human resource development, technology development and skills formation, through the lateral migration of these resource-dependent industrial clusters into resource-independent industrial activities (Jourdan *et al*, 2012). These linkages are created in a number of ways. The classification by UNCTAD (2010), which is largely adopted by Jourdan *et al* (2012), includes forward (downstream) linkages, backward (upstream) linkages, linkages along technology partners and linkages that result from a spill-over effect. A simpler classification is proffered by Extractives Hub (2020a), which is explored in the sub-section that immediately follows.

4.2. Types of Mineral-Based Linkages

The diagram below shows that there are five seminal economic linkages, namely fiscal, production, side-stream, horizontal and consumption linkages.

4.2.1. Fiscal Linkages

Fiscal linkages have to do with the application of revenues collected from the mining sector in funding government budgetary requirements, including promoting economic diversification of the country (Extractives Hub, 2020b). Piffaretti (2013) calls them development linkages – that is, linkages that enable the nation to develop from the use of mining economic rent by government. However, Piffaretti indicates that development linkages go beyond the fiscal function of government to include the role of the financial sector in mobilization of savings from the mining sector, to promote diversification of the economy by investing in other sectors, to promote research and development, *et cetera*.

Extractives Hub (2020a) emphasizes the role of fiscal linkages in the form of use of taxes and royalties in diversification of the economy into non-commodity sectors. However, a caveat is included - that these linkages on their own, without the support of production linkages, are not adequate to destroy the extractive industries enclave nature for several reasons. These reasons include the limited control of government on mining companies profits and hence on profit tax revenue; the limited negotiation skills of government vis-à-vis mining companies as well as the former's inefficiency and ineffectiveness in revenue collection; mineral price fluctuations; the lack of transparency in mineral revenue management; and high levels of public debt in mineral-rich developing countries, which tends to swallow up the mining fiscal revenue.
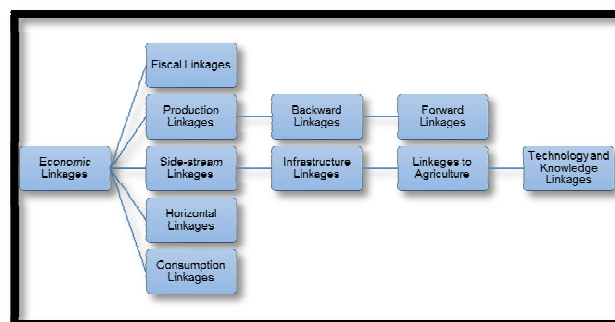

Figure 1: Types of Mining Economic Linkages (Extractives Hub, 2020a)

4.2.2. Production Linkages

Production linkages consist of upstream (backward) and downstream (forward) linkages (Extractives Hub, 2020a). Upstream linkages are linkages the mining sector has with its input sources, which inputs include machinery, equipment, protective clothing, security, technical services, financial services, etc. These linkages can be direct or indirect (UNECA, 2011), local or international (Al-moneef, 2006). Upstream linkages become more important as the complexity of extracting, processing and transporting mineral products increases (Aroca, 2001). It draws in large amounts of construction machinery and equipment, manufactured metals products, vehicles, water, scientific and technical services, electricity, business services, and transport and communication services.

Upstream linkages are closely associated with the advocacy for local procurement or local content policies (Extractives Hub, 2020a). Piffaretti (2013) identifies four types of mining suppliers in terms of local ownership and local value-addition as shown by the four quadrants in figure 2. Quadrant I represent the foreign importer – that is, the supplier is a foreigner (not a citizen of the country) who brings the stock into the country with little or no local value-added. Quadrant II is the foreign supplier whose supply is produced within the country, with significant or 100% local value-added. Quadrant III is the local producer who is a citizen, so that both local ownership and local value-addition are very high. The last quadrant represents the citizen who imports his stock or services which he then supplies to the mines. In the last case, local ownership is high, but local value-added is low. In order to promote greater linkages in the domestic economy, procurement should be concentrated on the locally-based foreign provider and the local provider, since this creates market for locally produced goods which has a multiplier effect on the economy. Imports dampen multiplier effect. The type of data required in assessing the current status and potential for development of upstream linkages include current and forecast production and investment, types of input requirements, current local procurement levels, factors constraining local procurement, *et cetera*.
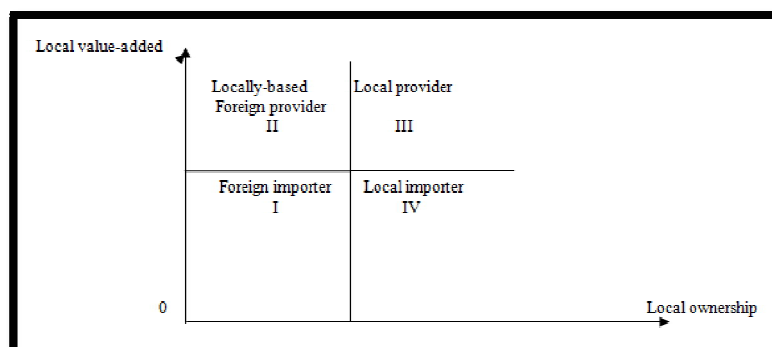

Figure 2: Categories of Suppliers (Piffaretti, 2013)

Downstream linkages refer to mining linkages that trace the interconnectedness of the mining sector to other sectors in the economy or regional or international economies that consume its output in the production process (UNECA, 2011). According to Jourdan *et al* (2012), forward linkages (downstream linkages) involve resource-processing (value addition) into intermediate products, semi-manufactures, components, sub-assemblies and finished resource-intensive products. Resource processing usually also produces co-products and by-products, which constitute additional potential feed stocks for further downstream linkage industries. Thus, downstream linkages go beyond mineral processing to include pre-treatment processes (plants), smelting, refinery, fabrication and manufacturing of end-user products.

4.2.3. Side-Stream and Horizontal Linkages

Development of the mining sector results in development of various forms of infrastructure required to support the sector (Extractives Hub, 2020a). These include railway lines, roads, water, ports, power, communication and logistics. 'Infrastructure linkages can help create a local industry because they promote the shared use of infrastructure for development' (Extractives Hub, 2020a). This has multiplier effects on the economy as these infrastructures can be used to catalyse agriculture and tourism activities, for example. Wisdom is decipherable in resource extraction negotiations which put infrastructural development as a condition, as this releases that aspect of the national budget for other uses. The above negotiation condition is further consolidated by the need on the part of mining companies to create good will and earn a social license to operate in the respective communities. The link to agriculture (and tourism) can also be appreciated from the fact that these sectors need to co-exist in the rural set-up and mining can have negative impacts on agriculture through land appropriation and degradation, pollution of water sources, etc. These negative impacts are mitigated through social corporate responsibility investments, which investments could target promotion of the agricultural sector beyond the mere automatic positive results of infrastructure development.

The development of the mining sector value chain entails a concomitant development of knowledge and technology (See Extractives Hub, 2020a), especially considering the knowledge intensive nature of both upstream and downstream industries. Some of these technologies and knowledges are specific to the mineral sector and some are non-specific. The latter can be transferred to other sectors of the economy, for example information technology, finance and engineering skills. Thus, side-stream linkages can also underpin the viability of other sectors and industries in the economy, which sectors or industries may not have any production linkages with the mining sector (See International Study Group Report on Africa's Mineral Regimes, 2011).

Horizontal linkages are associated with technology and knowledge linkages as they 'refer to skills developed in the extractives sector being transferred to other sectors. This includes cooperation between different companies in the same industry based on licencing, technology, joint buying and venture agreements.' (Extractives Hub, 2020a). The difference between knowledge and skill is that the former refers to theoretical understanding while the latter refers to the successful practical application of knowledge (theory) to get anticipated results (Difference Between, 2020). This also apparently includes softer issues of the mining sector practice that can be adapted to other sectors including business models.

4.2.4. Consumption Linkages

This refers to the effect on spending and hence structural transformation of the local economy due to rises in wages and profits in mining sector (Extractives Hub, 2020a). These linkages are dampened by lowering of earnings in the mining sector, importation of goods using the earnings from the sector and increased profit repatriation. These linkages tend to be greater during phases of the mining project when a lot of people are employed, for example, the construction phase and they tend to benefit agricultural products, transport services, hospitality industry, construction materials sector and services local to the mining community.

4.3. Conceptual Framework

4.3.1. Development Based on Resource-Linkages

How a country can reap the benefits of mineral resource endowments in terms of translating mining-led growth into development still remains a critical theoretical and empirical question. This question finds context in resource-based development theory, which may be split into two main traditions – the pessimistic and the optimistic traditions (Maleki, 2010). The pessimistic view, which is based on the exhaustibility of natural resources, has been popularised as the *resource curse thesis*. The optimistic tradition is founded on the international trade theory of comparative advantage and the export base theory of diversification and development through five stages, which theory emphasizes the development of linkages in the local economy.

Under the optimistic tradition it is envisaged that the development of linkages based on a particular resource sector (mining in this case) goes through four stages (Ramos, J., 1998, as cited in Jourdan *et al*, 2012, p.56 of the draft report) or five stages (Auty, n.d.) during which the comparative advantage in the resource sector is eventually converted into a competitive advantage which is anchored on both the particular resource-sector, other resource sectors and resource-independent sectors. The first stage is when resource extraction mainly depends on imported inputs (capital goods, consumables or materials and engineering services) and there is little local value-addition of the resource outputs before they are exported.

The second stage as expounded by Auty (n.d.), which phase Jourdan *et al* omits, is the increase in the scale of production and export which yields reduction in unit costs of production (through internal and external economies of scale) and increases the resource products' competitiveness. But investment essentially still resides within the particular

resource sector. In the third stage, which is apparently the second stage in Jourdan *et al*, upstream linkages develop in the form of investment in local input supplies, machinery and spare parts (import substitution, beginning with lower-technology inputs increasing to higher technology inputs), as well as increased local value-addition (smelting, refinery and fabrication plants) and increased production engineering services.

In Auty's fourth stage (which apparently encompasses Jourdan *et al*'sthird stage) there is capital overflow from the particular resource sector to household goods industries (to meet increased demand for non-tradables) as well as to mine-input or supplies producing sector, which sectors may eventually export (excess). It is at this stage that there is firm development of fiscal linkages as the government increases its capital development budget (infrastructure and human capital) as well as expenditure on programmes that promote further economic diversification. Auty's fifth (Jourdan *et al*'s fourth) and final stage is reached when the economy has matured, and exports a diversified range of resource goods, manufactured goods and services including engineering services. The country, no longer depends on mineral exports, but on several resource exports (at various stages in the product value-chain), manufactured goods and high-technology-product and expert-services exports.

This then shows how the mining sector can catalyze development of diversified economies (Auty) through development of 'resource linkages industrial clusters where the different components reinforce one another and, from initially serving local demand, develop competencies to export goods and services to resource sectors in the region and ultimately globally' (Jourdan *et al*, 2012, p.55 of the draft report). Clearly, the failure to develop optimal resource-based linkages would keep a country in the first stage (and at most second), where it remains a net exporter of primary products, holding the comparative but never the competitive advantage wherefore it can compete globally. The essentially silent but overriding assumption of the development process just described is a concomitant knowledge-intensification process (human capital or HRD development and technology product development or R&D).

The essential question of linkage development status in Zimbabwe is: To what extent has Zimbabwe, using its diverse mineral resource base, developed: import-substituting input; engineering and other expert consultancy (knowledge-intensive) service supplies; a diversified primary-resource export sector; highly value-added resource exports (secondary-resource export sector); and manufactured and high-tech exports; buttressed by elaborate infrastructure (power, transport, utilities), human capital development and a sustainable R & D infrastructure?

4.3.2. Input-Output Model

The framework expounded here is mainly based on Godana (1997) and Chiang (1984). The analysis shows how the various productive sectors are linked in terms of input supply, and hence addresses both upstream and downstream inter-sectoral linkages.

Suppose:
- n = number of industries or sectors in the economy
- a_{ij}= required input of good i (that is, input from sector i) per unit of output j. This is termed intermediate input, which can be manufactured or no manufactured goods.
- $a_{ij}$is fixed (that is, input-output technology is fixed)
- There is a final demand component for each industry y_i. This includes exports, investment, inventories, final consumption (government, non-profit bodies and households) (CSO, 1988).
- x_i = the gross output of industry i
- There is a primary input component so that:

$$\sum_{i=1}^{n} a_{ij} < 1 \tag{1}$$

The primary input component includes input supplied by households (labor), government (the business environment which is paid for by tax) and imported inputs of any kind (www.sfu.ca/~heaps/368/368IO.pdf). Taking the primary input into account the summation in equation (1) equals 1 (which is identical to the \$1 output value of output sector i).

From all the assumptions above, we can write:

$$x_i = \sum_{j=1}^{n} a_{ij} x_j + y_i \tag{2}$$

The first term in the right-hand side of equation (2) is the total intermediate demand for industry i's output, while the second term is the respective final demand. In matrix form equation (2) is denoted as:

$$\begin{bmatrix} x_1 \\ x_2 \\ . \\ x_n \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ . \\ x_n \end{bmatrix} + \begin{bmatrix} y_1 \\ y_2 \\ . \\ y_n \end{bmatrix} \tag{3}$$

The first matrix on the right-hand side of equation (3) is termed the technical coefficient matrix, consisting of coefficients representing intermediate input linkages (from i to j). The solid lines in the matrix trace a particular sector of interest (mining in our case) as a source (horizontal line) and as a market (vertical line) of intermediate input. The column sum is what is given by equation (1).

The system (equation 3) can be further summarized to:

$$X = AX + Y \qquad (4)$$

where all symbols (letters) are matrices, and A is the technical coefficient matrix. The coefficients along the mining sector column reflect the direct impacts (or first-round effects) of a \$1-change in the output of the mining sector on the output of other sectors which supply it with inputs (Rudawsky, 1986), as the former change creates demand for the latter sectors. However, the technical coefficients ignore indirect or chain-reaction effects (through the wider inter-industry linkages).

Equation (4) solves to the matrix of levels of industrial output (X) for the n industries, which would be able to satisfy both intermediate and final demand in the whole economy (that is, solution to equation 3):

$$X = (1 - A)^{-1} Y \qquad (5)$$

where $(1-A)^{-1}$ is the Leontief inverse matrix.

Unlike elements of the technical coefficient matrix above, each entry (b_{ij}) in the Leontieff inverse matrix gives 'the amount of product i (row sector) required for the production of one dollar's worth of product J (that is the technical coefficient) and indirectly for the production of all inputs (in every other sector) that are required for the production of that one dollar's worth' (CS0, 1988, p.iii). For example, the coefficient for mining-manufacturing link (with manufacturing as row sector) shows how much manufacturing should produce to supply mining sector directly and also to supply all the other sectors to enable ultimately the mining sector to be able to produce and meet a dollar's worth of its final demand. This then reflects the total dependence of mining production on manufacturing production; hence the Leonteiff inverse coefficients are termed interdependence coefficients. The matrix is termed interdependence coefficients' matrix or multipliers' matrix (Rudwasky, 1986).

The interdependence coefficients incorporate both direct and indirect effects (i.e. total effects) of final demand increase on a sector (Pissarenko, 2003). Note that, the total effect of a unit increases in final demand for product 1 on the output in the whole productive sector would be $\sum_{i=1}^{n} b_{i1}$. This is the output multiplier of sector 1's final demand[iv]. That is, the 1st column sum of interdependence coefficients. The total direct effect on all sectors, which is only a part of the total effect on all sectors, is the column sum of technical coefficients.

We can compute the following multiplier (See also Econ & Bus Geog, 2002):
Gross output multiplier per unit change in mining output (direct and indirect effect): $m_j^g = \sum_{i=1}^{n=8} b_{ij}$ (6)[v]

where:
$m =$ multiplier
$b_{ij} =$ inter-industry dependence (Leontief inverse) coefficient

4.3.3. Stability of the Input Coefficients

The usefulness of the I-O model in practical analysis is based on the stability of the technical coefficients (seein www.stat.go.jp; Econ & Geog, 2002). The assumption that has been made is that these coefficients are fixed; that is, the coefficients are stable. It is important to discuss what actually would make these coefficients unstable. These factors are subsequently discussed (See detailed treatment in www.stat.go.jp; Econ & Geog, 2002).

Production technology: the input coefficients are given for a particular year – that is, the year the IO table was compiled. Therefore, they reflect the production technology of the compilation year. However, if production technology changes over the years, the coefficients may change. 'Although drastic changes are generally not supposed to occur in production technologies in short time frames, in countries such as Japan, extremely rapid technological advancements may make it necessary to acquire information on changes in input coefficients and make proper adjustments by some method' (www.stat.go.jp, p.81)[vi]. Wolff (n.d.) argues that if technology changes significantly estimates of economic relationships may change (become obsolete). However small changes in technology have 'small impact on the Leontief inverse of an empirical input-output model, in which case the model's projective power can be maintained' (Wolf, n.d., p.2)

Production scales of entities in industries: each industry in the I-O table is a composite industry, comprising several 'enterprises and establishments' (www.stat.go.jp, p.81). The scales of these entities may change with time leading to changes in the structure of the industry in terms of input coefficients, even if the industry continues to produce the same goods. Note that even though constant returns to scale (CRTS) have been assumed, if a sub-industry in an industry increases both its output and inputs by the same factor, the industry as a whole would not necessarily experience CRTS unless all entities have scaled by the same factor. The stability of input coefficients in this case has been assumed on the basis of another assumption that each industry is homogeneous – that is, produces a homogeneous product. It is obvious that if the technologies *per se* are not linearly homogeneous, any change in scale would change the input coefficients

Relative prices: since the valuation of entries in the I-O table is at prices of products at the time of compilation; the mere changes in relative prices, even without actual technological changes, would change the input coefficients. That is, if the relative prices change significantly, even if the physical input coefficients or ratios do not change, the monetary input ratios will change. 'Historical comparisons would require Linked Input-Output Tables based on fixed price valuations, in which effects of fluctuating relative prices are eliminated' (www.stat.go.jp, p.81). See also in Chiang (1984, p.116) on the question of relative prices.

Product mixes: a re-configuration of industries in terms of combinations of products forming them will change the industries' input coefficients. Note that a similar effect will result from development of new products or disappearance of products from the economy.

4.4. Results on Mining Production Linkages from Studies in Other Countries
According to Hansen (2014, as cited in CCSI, 2016, p.22) local linkages between the extractive sector and the local African economies are few and weak, as suggested by value chain literature, due to the lack of interest by policy makers on development of upstream linkages. There are still stereotyped convictions that this industry is an enclave and that either the sector's technology is too high or too low for the sector's participation in its supply chain and adaptation into other sectors (Kaplinsky, 2011, as cited in CCSI, 2016, p.22). In order to strengthen upstream linkages lessons from case studies show that the following are critical (CCSI, 2016):

- Development by Government of an effective local content policy which is realistic, progressive over time, emphasizes increasing local value addition vis-a-vis local ownership, and whose achievement is monitored by a dedicated national body (as in Nigeria and Australia); and
- Development by companies of a local procurement plan for each project, which plan should be agreed with Government as the latter has important interventions to make to ensure the plan is carried forward. Development partners can play the role of neutral arbiters. The cases of South Africa and Australia demonstrate the need to address constraints that limit local suppliers which can include infrastructure, finance and technology. A tripartite effort involving government, mining companies and international development agencies is key in addressing these structural gaps.

On downstream linkage development valuable lessons can be drawn from the cases of Australia, Japan, Botswana, Indonesia and Mozambique (CCSI, 2016). Various tools have been used (apparently with success) in various countries. For example, in Indonesia export taxes or restrictions (prescriptive tools) were used, Botswana used negotiation and renegotiation of existing contracts, and Mozambique used incentives. In each case a good cost-benefit analysis of each tool should be done because the net benefit may not be so easy to anticipate with pedestrian attitude.

In the study of Chilean II Region mining sector by Aroca (n.d.) an output multiplier of 1.30 was obtained, which was deemed to be weak. Mining constituted 60% of GDP of the Chilean II Region. Several sectors including Fishing, Utilities, Business Services and Public Administration exhibited greater Type I multipliers than the mining sector. Type II multiplier in Chile was 1.8. Considering Type I multiplier the mining sector was linked mainly with the Business Services, utilities (energy) and Retails sectors. However, considering Type II multiplier the sector was, in addition to the above, also significantly linked to Manufacturing, Transport and Communication, Real State and a group termed Other Services.

In another study by Stillwell *et al* (2000) on the impact of mining activities on the economy of South Africa between 1971 and 1993, it was concluded that government had overestimated the importance of the mining sector to the national economy. They found that mining production changes did not have impacts that were significantly different from those of most of the other sectors. Mining linkages with the rest of the economy were found to be few. A study by Eggert (2002), cites the output multiplier for Western Australia's Mining and Mineral processing sectors to average 2.2 (including induced consumption) in 1995.

5. Methodology

5.1. Application of Input-Output Model
This study applies the Input-Output (Leontief Model) to come up with quantitative indicators of mining linkages in Zimbabwe. Input-Output analysis has been used by Stilwell et al (2000) in analysing the impact of mining on South African economy. Aroca (n.d.) also used the same technique in studying the impact of the mining sector on the diversification and development of local economies with particular reference to the Chilean II Region.

The empirical analysis uses two sets of data and information namely, the Input-Output data of 1980 published by the Central Statistical Office (now ZIMSTAT) in 1988 (CSO, 1988) and the data from a partial mining industry survey conducted in January and February 2014. Using the input-output, the paper attempts to give a quantitative interpretation of linkages. The major indicators from this base case are then adjusted to 2014 by intuitively deduced possible violations of typical assumptions of I-O models occasioned by economic changes between 1980 and 2014. The deductions are complemented by indications from the - mining industry survey.

The latest available I-O data for Zimbabwe is for 1980 in CSO (1988). The industries included number up to 61 because sectors are in many cases split into various specific products. For example, the primary mining industry is split into chrome; copper, nickel and cobalt; gold; iron ore, stone and sand; asbestos; phosphate prospecting; and other minerals. Mineral processing and beneficiation are split into petroleum, petroleum and coal products; iron and steel basic products; non-ferrous metal basic products; and so forth. The 61 industries were consolidated into eight sectors according to type and the respective technical coefficients were summed up accordingly.

Statistics given in CSO (1988) include the matrix of technical coefficients and the final demands for all the 61 industries. From this data we can view the direct (first round) mining linkage coefficients by following each primary and secondary mineral product in the coefficient matrix along the rows (for significance as a source of intermediate input) and along columns (for significance as a market). This gives us direct linkage effects of the mining sector in the two senses.

Input-Output data takes a long time to compile and is expected to remain valid (at least) for 10 years (see in CSO 1988). In the absence of any recent data the latest available remains the reference data.Thus, this section carries out the analysis on the basis of the 1980 data and gets results pertaining to 1980. In many cases the data remains valid for many decades because the data shows the structure of the economy in terms of production relationships (technology of production) and not relative output levels.

To what extent this 1980 structure can be applicable to the 2014 period, more than three decades later, is an important question. In other words, the question is: What would make this structure change? This study will attempt an

adjustment of the 1980 results for to take into account any possible changes in input-output coefficients as determined by: (i) Changes in technology in the local productive sectors; (ii) diversification of the economy which would create more sectors (or change in product mixes in particular sectors)– for example, advent of new local manufactured products (innovation); (iii) changes in the relative prices of goods and services in the economy; (iv) input substitutions in response to relative price changes or technological changes; and (v) changes in product mix.

5.2. Mining Industry Survey

A comprehensive questionnaire was administered to mining and exploration companies to get their views and information about their operations which would assist in deducing production mining linkages. The questionnaire was also intended to be administered to mine suppliers as well as other stakeholders. No formal sampling procedure was used as the survey intended to cover as many respondents as possible, and for mining and exploration companies as many as were on the Chamber of Mines of Zimbabwe register. The data collection exercise was a combination of electronic questionnaire responses and personal interviews based on the same prepared questionnaire.

While all the questions in the questionnaire would be useful in any general discussion of the impact of mining on an economy, the questionnaire had specific questions relating to areas such as beneficiation and value addition, the destination of the respondent's product, the distribution of operating costs by sector for 2012, skilled manpower supply conditions, expenditures on corporate social responsibility, re-investment and investment in various sectors by the mine, local procurement of services and materials, etc.

Out of the expected more than 30 targeted mining and exploration respondents only 12 were successful. Thus, the results in this report are based only on these 12 respondents. These covered, in terms of mining subsectors, gold, chrome, platinum, coal and diamonds. The three tables below (Table 2, 3 and 4) show the demographics of the respondents.

	Frequency	Percentage (%)
An exploration company	1	8.3
A producer company with turnover of less than US$5m/a	2	16.7
A producer company with more than US$5m/a	5	41.7
Exploration and Producer company with turnover of less than US$5m/a	2	16.7
Total	10	83.3
No response	2	16.7
Total	12	100.0

Table 2: Distribution of Respondents by Type of Company
Source: Author's Analysis

Frequency (%)	(%) of Ownership	
	Indigenous	Foreign owned
4(33%)	100%	0%
6(50%)	0%	100%
1(8%)	15%	85%
1(8%)	40%	60%

Table 3: Distribution of Companies by Ownership Status
Source: Author's Analysis

Position	Frequency	Percentage (%)
Company Chairman	1	8.3
Managing Director	1	8.3
Executive Director	2	16.7
General Manager	3	25.0
Other Senior Management	3	25.0
Other	2	16.7
Total	12	100.0

Table 4: Distribution of Respondents by Position in Companies
Source: Author's analysis

6. Results and Interpretations

This section reports and discusses the quantitative results on production mining linkages obtained from the application of the Leontief Model on Zimbabwe's Input-Output data for 1980 and their extrapolation to the 2014 period.

6.1. Direct Production Linkages

6.1.1. Direct Downstream Linkages

Table 5 is the table of technical coefficients. Along the highlighted row we have the amount (in $) of direct input from the mining sector per $1 worth of output produced in each sector of the economy. Each element in the highlighted

row can be represented by a_{2j} where 2 denotes that the row sector (the input supply sector) is the mining sector and j indicates the jth output sector (a sector using mining input as intermediate input). Thus, for every \$1 worth of output produced in agriculture mining contributed \$0.0052 worth of direct input; for a \$1 worth of output in the mining sector itself, mining contributed \$0.0119; for a \$1 worth of output in manufacturing, mining contributed \$0.0219; *et cetera.* It is important to emphasize that these coefficients indicate what the mining sector supplied directly to the sector concerned, not indirectly through other sectors, hence we call the linkages represented direct downstream production linkages.

Another equivalent way of interpreting the row coefficients is that, each coefficient gives the proportion of a sector's output (which is equal to input costs or input requirements, if the product is valued at input cost) which was constituted by direct mining input. Thus, mining directly met 0.5% of input requirements in agriculture, 1.2% in mining itself, 2.2% in manufacturing, 1.0% in electricity and water composite sector, 1.9% in construction, 0.2% in finance, insurance and real estate composite sector, 0.2% in transport and distribution composite sector, and 0.1% in public administration, education, health and other services. This gives an average direct mining input requirement for a sector in the economy of 0.9%. This is significantly lower than the average direct input requirement from manufacturing (10.5%), transport and distribution (5.6%) and water and electricity (1.4%). Thus relatively, mining was not an important direct source of input for other productive processes in the economy, given the technologies of production. However, much should not be read into this as a failure of the mining industry since this depends on the productive technologies used.

Sectors		Technical Coefficient Matrix (Intermediate Inputs)							
		X1	X2	X3	x4	x5	x6	x7	x8
Agriculture	x1	0.06453	0.00021	0.083774	0.000117	0.001735	0.000342	0.000012	0.003626
Mining	x2	0.00521	0.011893	0.021944	0.010352	0.019284	0.001679	0.001847	0.000739
Manufacturing	x3	0.16456	0.112212	0.215707	0.017576	0.170856	0.030261	0.03842	0.091429
Electricity/ water	x4	0.01682	0.040335	0.010229	0.274533	0.001598	0.000415	0.005743	0.011941
New Buildings	x5	0.02772	0.001223	0.00216	0.000232	0.036709	0.01497	0.005648	0.008568
Fin, Insu, Real Esta.	x6	0.01208	0.004969	0.011438	0.009578	0.014246	0.023831	0.015778	0.022274
Transport /Distribut.	x7	0.09359	0.03423	0.06168	0.018001	0.059989	0.053763	0.078309	0.048225
PA, Edu, Heal, OS	x8	0.01203	-0.000001	0.000172	0	0.066159	0.106816	0.030223	0.027942
Column sum		0.3965	0.205071	0.4071	0.3304	0.3706	0.2321	0.1760	0.2147
Gross Value-added (primary input)[vii]		0.6035	0.794929	0.5929	0.5596	0.6294	0.7679	0.824	0.7853

Table 5: Consolidated Technical Coefficient Table
Source: CSO (1988) and authors' analysis

6.1.2. Direct Upstream Linkages

Each element (coefficient) in the highlighted column of Table 5 shows how much ($-value) input the mining sector directly required from the other sector per each $1 worth of mining output produced. This is the column that is summed in equation (1). The coefficients in this column can also be interpreted as proportions. Therefore, of the direct input requirements of the mining sector, in percentage terms, the manufacturing sector supplied 11.22% (or $0.1122 per $1 of mining output), electricity/water 4.03%, transport/distribution 3.42%, mining 1.19%, finance, insurance and real estate 0.5%, construction 0.12%, and so forth. Thus, the manufacturing sector, electricity/water composite sector and transport/distribution composite sector were (in that order) significant direct suppliers of input to the mining sector. The primary inputs into the mining sector constituted 79.5% of total input requirements for the sector. With an imported-input component of 0.0986 and an earnings component of 0.2314, this leaves taxes and gross operating profit constituting 0.465. The imported-input component at about 10% was significant.

6.2. Output Multipliers

6.2.1. Total Downstream Linkages

Table 6shows total linkage coefficients or industry-interdependence coefficients. The 8x8 matrix of coefficients in the table is the Leontief inverse matrix defined in equation (5). Each element in the highlighted row now depicts the total input requirements from the mining sector (in $) for each $1 worth of output in the sector indicated above it. This includes the direct requirement in Table 5 and the indirect inputs from the mining sector which were supplied to other sectors that supplied the particular sector to enable it to produce $1 worth of output. For example, since the mining sector directly supplied $0.021944 per unit ($1 worth) of manufacturing output (Table 5), the coefficient 0.0252 in Table 8 indicates that the mining sector also supplied indirectly (through other sectors such as agriculture, electricity/water and transport/distribution) $0.0033 (= 0.0252 - 0.021944) per $1 worth of manufacturing output. The total coefficient can also be interpreted as a proportion or percentage of manufacturing output (2.5%). Besides the significant total linkage with itself amounting to 87.73% (the mining sector funded a major part of its own production, either through direct inputs or through inputs purchased from its own sales revenue, albeit it could also borrow to finance production), total downstream production linkages with the rest of the economy were weak indicating low direct and indirect linkages. There was only a slight linkage with the construction sector which used some building materials.

Sectors		Leontief Inverse							
		x1	x2	x3	X4	x5	x6	x7	x8
Agriculture	x1	1.1154	0.0022	0.1393	0.0006	0.0044	0.0051	0.002	0.0235
Mining	x2	0.0132	0.8773	0.0252	0.0212	0.0368	0.0034	0.0034	0.003
Manufacturing	x3	0.2224	0.1241	1.3023	0.0294	0.2253	0.0544	0.0582	0.6218
Electricity/water	x4	0.0407	0.076	0.0327	1.4793	0.0148	0.0049	0.0125	0.0245
New Buildings	x5	0.0332	0.0028	0.008	0.0009	1.0423	0.0173	0.0069	0.0104
Fin, Insu, Real Esta.	x6	0.0205	0.0083	0.02	0.0178	0.0206	1.0284	0.0192	0.0157
Transport/Distribut.	x7	0.1359	0.0464	0.1024	0.0304	0.0872	0.0705	1.0906	0.2995
PA, Edu, Heal, OS	x8	0.0226	0.0021	0.0068	0.0018	0.0799	0.1245	0.0385	0.805
Gross Output Multipliers (column sums)		1.6039	1.1392	1.6367	1.5814	1.5113	1.3085	1.2313	1.8034

Table 6: Leontief inverse for Zimbabwe
Source: CSO (1988) and Authors' Analysis

6.2.2. Total Upstream Linkages (Multipliers)

An increase in final demand for mining output of $1 would trigger increases in production in the sectors supplying inputs to the mining sector. Each of the supplying sectors would increase its output by the amount in the highlighted column in Table 5 to meet the $1 increase in mining output (as a result of $1 exogenous increase in final demand for mining output). This is the first-round effect. For example, in the first-round manufacturing would increase its output by 1*0.112212, electricity/water by 1*0.040335 and so forth. The second-round effect comes from the fact that the increase in production in the supplying sectors triggers increase in demand for their own input in turn. That is, the manufacturing sector would demand, for instance, 1*0.112212*0.010229 from the electricity/water sector, 1*0.112212*0.00216 from the construction sector, 1*0.112212*0.083774 from agriculture, et cetera. This iterative process goes to the third round, fourth round, and so forth. While the process can be continued, empirically it has been shown that the effects become negligible after the third round (Pissarenko, 2003).

The total of these iterative effects gives the multipliers of the mining sector with respect to the various sectors from which it got its input, which are the elements of the highlighted column in Table 6. The greatest multiplier effect of the mining sector was upon itself for obvious reasons. The table shows that a $1 increase in final demand for the mining sector would ultimately increase output in the manufacturing sector by 12 cents, electricity/water by 8 cents, construction by 0.3 cents, transport and distribution by 5 cents, et cetera. The mining sector gross output multiplier (for the whole

economy), a sum of the individual sector multipliers with respect to mining, was 1.14. This means that an initial increase in final demand for the mining sector of $1 would ultimately translate into $1.14 in national output after all necessary sectoral adjustments to the shock. The gross output mining multiplier was the lowest among the eight sectors, which suggests that the sector had the largest withdrawals in the form of imported-input and tax components (with the latter paying for Government environment) in its output.

6.3. Summary of I-O Quantitative Measures

Table 7 and its respective graphical representation (Figure 3) depict a summary of the above results.

Sector	dld	dlu	Ild	Ilu	tld	somm	gosm
Agriculture	0.0052	0.0002	0.008	0.002	0.0132	0.0022	1.6039
Mining	0.0119	0.0119	0.8654	0.8654	0.8773	0.8773	1.1392
Manufact.	0.0219	0.1122	0.0033	0.0119	0.0252	0.1241	1.6367
Elect/water	0.0104	0.0403	0.0108	0.0357	0.0212	0.076	1.5814
New build.	0.0193	0.0012	0.0175	0.0016	0.0368	0.0028	1.5113
FIRE	0.0017	0.0050	0.0017	0.0033	0.0034	0.0083	1.3085
Trans/distr.	0.0018	0.0342	0.0016	0.0122	0.0034	0.0464	1.2313
PEHO	0.0007	0.0000	0.0023	0.0021	0.003	0.0021	1.8034

Table 7: Summary of Mining Linkages Indicators from the Input-Output Analysis
Source: Author's Analysis

Denotations:

dld – direct linkages downstream (highlighted row in Table 7)
dlu – direct linkages upstream (highlighted column in Table 7)
ild – indirect linkages downstream (= tld-dld)
ilu – indirect linkages upstream (= somm-dlu)
tld – total linkages downstream (highlighted row in Table 6)
somm(= tlu) – Total mining linkages upstream = sectoral output mining multiplier (highlighted column in Table 6)
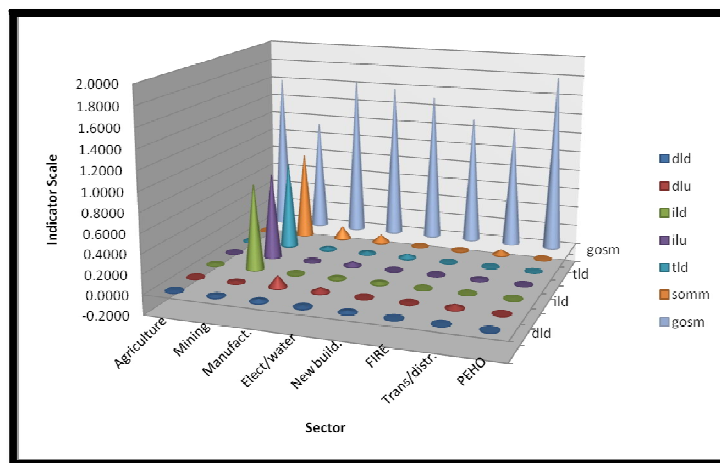gosm – gross output sectoral output multipliers (column sums in Table 6)

Figure 3: Mining Production Linkages Indicators

6.4. Adjustment of the 1980 I-O Results to 2014 Period

In this section we discuss the likely changes to the above results due to the passage of time. Technical progress, which is the ability to produce more with the same or less amount of capital and labour (hence at lower unit costs), can either be developed through research and development (R & D) or adopted (importation of better equipment or management systems). With little or no investment in R & D, that leaves adoption. Production technology, which is most relevant in production relationships, had not changed significantly in Zimbabwe between 1980 and 2014. Most sectors, in the latter year,were saddled with old equipment embodying the technology of the 1980s. In particular, mining technical progress in Zimbabwe had been affected by the difficulty for technology adoption in a sector where most of the firms were small-scale by international standards, given that mining technology is developed by large multinational companies for large-scale operations. In Zimbabwe, one study has shown that mining production technology had actually gone down (Mlambo, 2010a). It is a fair assumption that technology had basically remained stagnant in the whole productive sphere of the economy over the 34-year period.

The national accounts published by ZIMSTAT, show that essentially the type of commodities in the economy had not changed significantly. The various sectors exhibited in the 1980 I-O tables were still the same sectors in existence by 2014, save for small changes within particular sectors; for example, in the mining sector platinum production had become

predominant, while tin was no longer being produced in any significant quantities. It is important to note that, mere changes in output levels do not, per se, change input coefficients in the economy.

One key assumption of the I-O model is that relative prices of intermediate inputs and primary inputs (mainly labour) do not change significantly. The extent to which relative prices had changed and the extent to which this had induced input substitution can be ascertained through a detailed study. However, suffice to say that the existing technology at any time limits the extent to which input substitution can take place due to the law of variable proportions (diminishing returns to a factor) – any radical changes would necessitate a different underlying technology.

The imported-input component in the economy had certainly increased over time, since with reduction in the local capacity to supply due to the progressive economic crisis, mines and firms in other sectors like manufacturing had to substitute local input supply by imports. The implication here is that the multiplier effect had been dampened. The general recession rules out the possibility of any significant feedback effects from the import suppliers, except possibly in terms of labor export whose net effect on the economy (gross output) is ambiguous though generally thought to be deleterious. The earnings component of mining output was 0.2314 in 1980, and from the survey (2014), it had increased to 0.3363 (from the average of 8 reporting companies). Assuming a uniform increase in the primary-input component then the import component increased at the same rate as the labour component. We can estimate that the imported-input component had increased from 0.0986 (for 1980) to 0.0986*(0.3363/0.2314) (= 0.1433) (for 2014).

It is important to weigh the above point (effect of increased imports on the multiplier) against the reduction in scale as a result of the economic crisis. A reduction in scale would not by itself affect the technical coefficients (input coefficients), hence would not affect the multipliers. However, it may be argued that a combination of scale reduction and increase in relative share of imported inputs and labour (primary input), would lead to any resultant reduction in the multiplier due to the latter being moderated by the response of scale reduction.

It is expected that the 1980 findings on downstream linkages (both direct and total) remained generally valid for 2014. From the survey 41.7% of the respondents indicated that in 2012 they had supplied some of their output as input into the domestic economy, while the remainder (58.3%) indicated that they had exported all their output. While a clear quantitative conclusion on direct downstream linkages is difficult to make from the survey, it is interesting that the survey shows the same order of significance in terms of the first three sectors receiving inputs from mining – that is, manufacturing, electricity/water and transport/distribution.

The findings on total upstream linkages will have to be revised downwards – that is, both sector specific multipliers and the gross output multiplier were lower in 2014compared to 1980 due to increased import of inputs. However, since the economic crisis resulted, apart from more imports, in production scale reduction, it may be expected that the reduction in the multipliers had gone down moderately. Since the multiplier is simply a sum of *tlu*'s (which are themselves sums of direct and indirect linkage effects), increased import component, *ceteris paribus*, directly reduces direct upstream linkages by the same points. Thus, the change in import-component of 0.0447 (= 0.1433-0.0986) provides the upper limit to reduction in multiplier which is then moderated by scale reduction. Thus, the 2014 gross output mining multiplier would be expected to lie between 1.10 and 1.14 (rounded off).

If we assume the 2014 multiplier to lie half-way, then it would be 1.12, which is still significant. This would mean that if mining output increased by say 20 billion Dollars then total gross output in the economy would increase by 22.4 billion Dollars. Since this multiplier takes only production linkages into account, a total multiplier (Type II) that takes into account the induced effect of household expenditure from their incomes (emanating from the mining sector employment) would certainly increase the multiplier to above the upper limit (that is, beyond 1.14).

If the increase in final demand for mining output were to warrant capital expansion, this would most likely create new expenditures on corporate social responsibility (CSR), which in turn would create exogenous demands in other sectors of the economy. In this case the gross output mining multiplier would even be enhanced by the multipliers in other sectors. CSR as a percentage of gross mining investment in 2012 ranged from 1.3% to 10% for a responding mine – averaging 5.9% for each mine. This was a very significant exogenous shock to those sectors or sub-sectors in which the expenditures were carried out, for example education and health. In such case, the ultimate economy-wide gross output change significantly went beyond that related directly to the gross output mining multiplier.

6.5. Qualitative Results from the Survey on Production Linkages

This section reports and discusses results from the 2014 survey of mining and exploration companies related to production mining linkage development.

6.5.1. Downstream Linkages

Most of the respondents from the survey said that they beneficiate their output. However, it is clear that most of the mineral output is exported after basic processing, with the exception of gold which is refined by the Fidelity Printers and Refineries and exported as bullion. Thus, the beneficiation referred to in the responses appeared to be 'ore beneficiation' which is mineral processing. The final result of this process is a concentrate though one platinum mine goes beyond the concentrate to produce matte and one chromite miner indicated that they were also smelting their chrome.

Several impediments to establishment of beneficiation facilities in Zimbabwe were cited. In summary these included power scarcity, power unaffordability, water problems, huge financial outlays, limited feed, viability problems, lack of technical expertise and legislated centralization of gold refinery. These were effectively impediments to development of downstream linkages in the mining sector. Most of the respondents in the survey (miners) acknowledged that significant scope existed for further beneficiation of their output, with some indicating plans to upgrade their facilities. Most of them were exporting their product, with some exporting 100% of it.

Almost all miners depended on the national grid for their power supply. Initial establishment of access to and monthly bills on power were found to be not affordable. While there had been a gradual improvement in power supply in the preceding five years, power had remained highly inadequate and outages were still common. Beneficiation facilities demand a lot of power supply. So, do they demand water, which is another important utility requirement for beneficiation facilities. While generally, the survey showed that monthly bills for water were affordable, the cost of establishing initial access to water was not affordable. Transportation facilities were not in good form especially the critical rail service which was affected by old age and lack of spare parts.

Beneficiation facilities are massive. Beneficiation plants have large minimum technical and economically optimal scales of operation which require huge financial outlays in terms of initial investment capital and working capital. One respondent cited one model in which the beneficiation industry had to be supported by an exclusive banking sub-sector (some kind of 'beneficiation bank'). Another respondent indicated that as much as US$700m and US$3b would be required to establish a smelter and a refinery respectively. Thus, the huge minimum scales are a significant barrier to entry into this part of the value chain. The cost of upgrading and retooling existing and dysfunctional facilities was also very huge.

The large scales of operation imply the need for substantial primary mining output feed into the facilities. The existing capacity of the mining sector in Zimbabwe was inadequate to meet minimum need, unless primary production would be enhanced through reopening of closed mines or increased exploration and development of new mines. This appears unlikely especially if beneficiation or value addition and local procurement requirements were to be legislated. On average respondents identified requirements on value addition and local procurement to be more than moderate obstacles to investment in exploration and development. The facilities could depend on regional supplies of primary feed, but this regional capacity would need careful assessment before the facilities could be established. Competition already existed nearby with the South African mining sector failing to meet the needs of beneficiation facilities in that country due to underproduction.

The survey showed that most mining companies employed graduates from the University of Zimbabwe, the Zimbabwe School of Mines, polytechnic colleges and other training institutions in the country. There were few who had employed outsiders for lack of local skill. However, it was also indicated that the trend of skills supply in the country was worsening, with massive brain drain into the regional and international mining industry. Beneficiation is the most skill-intensive part of the mineral value chain. In 2014 there is no adequate appropriately skilled manpower to supervise or construct such facilities, let alone to run them.

In the gold sector, however, there was a view that Fidelity Printers and Refineries had a monopoly, and it would be better for this area to be liberalized. However, it is doubtful if this area would be easier than the rest in terms of the challenges discussed above.

6.5.2. Upstream Linkages

The mining sector procured a variety of goods and services locally such as some chemicals, fuels, lubricants, coal, certain oils, silica, chrome ores, coal, construction and civil engineering materials and services, some small equipment including ball mills, drilling equipment and explosives, protective clothing, blasting and mining services, transport, catering and management, plant maintenance and general hardware, *et cetera*. However, major equipment and spares, gear boxes, motors, roof support, bearings, and a great number of various laboratory consumables were imported.

Most mining skills were obtained from the local universities, technical colleges, the Zimbabwe School of Mines (the main supplier) and others. However, the trend in local skills supply was worsening. While educational infrastructure was improving at the Zimbabwe School of Mines through the support from Government and the Chamber of Mines of Zimbabwe (mining industry), this could not be said about other critical service providers like the Institute of Mining Research (IMR). Generally, geologists and mining engineers were scarce in the country to the extent that critical research institutes like the IMR operated entirely without them. This meant that the Institute could only offer a limited range of services to the mining industry. Also, the student-teacher ratio in training colleges and universities was very high. This, coupled with poor conditions of service at training institutions, resulted in compromised skill level of produced graduates. Thus, a wide range of expert technical services (consultants) were still imported.

The main problems faced with local procurement included: expensiveness, lack of reliability of supplies (supplies were not always available when needed), outright non-availability, poor-quality supplies, poor back-up service, long time to deliver, and need for upfront payment (for most suppliers). However, most of the respondents were not concerned about whether suppliers were certified in certain international standards, and only a few (about 20% of the respondents) had tried to assist their suppliers to meet any standards. Most respondents had no shareholder interest in mine supplies indicating limited vertical integration backwards.

7. General Discussion of Results and Recommendations for Optimal Production Linkages Development

The Zimbabwe of 2014 could be positioned somewhere in phase III according to the phases of resource-linkage based development, where there is some input industry and some value-addition taking place, but that would be at the lower end of the phase (see Jourdan *et al*'s 2012 view on this). In fact, the results in this report show that direct downstream linkages were very low (averaging 0.9%), while total downstream linkages were slightly noticeable in the construction sector when one combines the use of building materials with some use of steel products in new buildings.

Several authors (Franks, 2020; Manning & Theodoro, 2020; Lebdioui, 2020) underscore the importance of the so-called 'development minerals' in development of production linkages, among other linkages, in the local economy. Lebdioul identifies the potential of these minerals to foster competitive advantages in agricultural, manufacturing and construction sectors (that is, production linkages) as their real values. Afeku & Debrah (2020) refers to the Africa Mining

Vision's balanced emphasis on both high-value and low-value (industrial and construction materials) as being important especially in diversifying the mining sector itself. Zimbabwe is a typical tragedy in this case, in that of the ten top minerals mined in Zimbabwe there is only one development mineral, asbestos. The production of, for example, graphite, phosphate, limestone, feldspar and magnesite, had remained relatively subdued in the two years and the intervening period considered by the study.

Several impediments to downstream linkages existed. Large financial outlays, which were the reason for the establishment of centralised beneficiation facilities in certain countries, for example South Africa, in the first place were still an important factor. We have also noted power supply level and affordability, water problems, transport (and logistics), lack of enough primary feed, lack of necessary expertise and competition with existing plants in neighbouring SA. It is clear that the government was trying to force beneficiation on miners without addressing the above impediments which were not the responsibility of the miner. The core-competence and core-business of the miner anywhere is to mine. Instead, incentives were supposed to be put in place to ramp up mining production by re-opening closed mines and promoting exploration and new mine development. This, which would be akin to activating stage two of the development phase of linkages, would create economies of scale (lower unit costs) and savings which could spill over to resuscitation of old smelters and refineries while creating a sufficient base of primary feed.

Most minerals mined in Zimbabwe were not refined (or beneficiated) locally, which represented scope for further beneficiation linkages as well as manufacturing (fabrication). Platinum Producers Committee of Chamber of Mines of Zimbabwe (2012) adequately explains this scope. The Committee indicated that the gold value-chain could be extended to gold jewellery; diamonds currently sold as rough diamonds could be cut and polished and be used to produce diamond jewellery; iron ore, nickel and ferrochrome provided the basis for a viable stainless steel industry in Zimbabwe; copper, which was currently sold as copper cathode, could be value-added to produce copperware and copper cables; PGMs could be taken beyond matte to base metal refinery, precious metal refinery and then production of jewellery, chemical catalysts, oxidation catalysts, alloys, *et cetera*. The list goes on. Beneficiation and value-addition bring with them many linkages related to supplies, ancillary sectors, downstream activities, fiscal scope, spatial relations, knowledge and product development.

Government could seek to promote downstream linkages by effectively addressing the impediments above, which would represent the best use of mining fiscal revenue and dividends paid against government mining equity. Thus, fiscal linkages could be used to catalyse downstream linkages. Downstream linkages could better be developed by enablers and incentives than by legislation and the inclusion of value-addition requirements into mining contracts. The model of phase development of linkages is based on business sense, not on coercion.

Direct upstream linkages with manufacturing, electricity/water and transport/distribution were noticeable, and addition of indirect upstream linkages made the upstream linkages with these three sectors reasonable. There was some local procurement of supplies, and significantly, of labour. A gross output mining multiplier of 1.14, while lower than in other jurisdictions such as Chilean II Region (1.30) and Australia (deduced to be lower than 2.2 but much higher than 1.14), was still a good starting point. In Zimbabwe mining constituted about 9% of GDP in 1980 (CSO, 1986). Thus, while the gross output multiplier of 1.14 is low, it is very comparable to that of the Chilean II Region of 1.30 given that in the latter mining constituted 60% of the gross output of the Region. We have shown in the above section that there were, like in the case of downstream linkages, several impediments to local procurement which needed to be addressed. A growing primary mining sector was also, as in the case of downstream linkages, a pre-requisite for development of upstream linkages as a growing mining sector would be able to support a sizable upstream industry (Jourdan *et al*, 2012). In this case the mining industry would be a market, and a large domestic market would facilitate development of capital goods and intermediate-input supply industry, which of course, must also deliberately find export markets to enjoy economies of scale.

Addressing the infrastructural constraints to mineral production (rail networks, roads, power, water, *et cetera*) would enable the actual realization of comparative advantage (Jourdan *et al*, 2012), since without that, resource advantage would simply be latent. The model of linkage-based development progresses from the activation of comparative advantage (through increased primary production) to eventual attainment of sustainable competitive advantage in Phase V. At that stage the economy would be no longer resource-dependent. It is important to understand that the competitive advantage in Phase V is not sustained by simple replication of physical facilities, but by knowledge-intensification processes. What perennial developing countries have failed to grasp is that the economies of the developed world are significantly dependent on human capital and technology/product development, and not on simple accumulation which is static.

However, the country needs not wait for stage five to deliberately address the knowledge equation. Like beneficiation, upstream industries are also knowledge-intensive, which requires investment in human capital development and research and development (see in Jourdan *et al*, 2012). Instead of building local content clauses into resource contracts, the government should build into resource contracts HRD and R&D requirements. This would entail the re-capacitation of mining training and research institutes, as well as funding postgraduate training and R & D.

To enhance upstream linkages there would also be need to initially create a common understanding between mines and the locally based suppliers of the current demand and demand projections on the one hand, and existing local supply capacities on the other (Piffaretti, 2013) – that is, address the information gap. While instituting requirements for local content by building local-content clauses into resource contracts, as some authors (for example, Jourdan *et al,* 2012) have advocated for can be useful where there is local capacity, it is useless where there is none. Such capacity needs to be ascertained, and more so to be deliberately incentivized. Vertical integration backwards by mines (into supplies business) is a business decision which should be subjected to the usual viability criteria. Government has greater responsibility to ensure the building of local capacity.

8. Conclusions

The paper concludes that downstream linkage development in Zimbabwe in 1980 and 2014 was weak. That is likely true of the intervening period and after if the general macroeconomic trends are anything to go by. Local beneficiation of minerals was affected by various infrastructural constraints, lack of the appropriate technical expertise and huge financial requirements related to the large minimum technical and economic scales of operations required. The paper has clearly shown the importance of the carrot vis-à-vis the stick and emphasis on the overlooked 'development minerals' if Zimbabwe wants to develop its downstream linkages optimally.

Direct and indirect upstream linkages existed with manufacturing, electricity/water and transport/distribution sectors, resulting in a gross output multiplier below but moderately comparable to those of other mining developing countries such as Chile. Critical constraints to upstream linkages include lack of technical expertise and finance. Lessons from other country studies have shown that two things among others are critical - development of an effective, realistic and institutionally monitored local content policy which emphasizes local value addition ahead of local ownership (as in Nigeria and Australia); and development of local procurement plans for all projects by the mining companies, which are agreed to and whose implementation is enabled (facilitated) by Government through necessary interventions to bridge structural gaps, with support of international development agencies.

Four overriding recommendations for optimization of production linkages emanate from this paper. These include infrastructural development (especially power, water and transport), increased primary production (for feed and market), larger expenditure on HRD and R&D, and provision of incentives rather than legislation. The critical role of Government in catalysing production linkage development demands greater fiscal space, fiscal prudence and good governance.

9. Study Limitations and Recommended Further Research

This research is limited by lack of current input-output data for Zimbabwe. When such data is generated by Zimbabwe National Statistical Office (ZIMSTAT), this study will need to be updated. However, as the paper shows, the Zimbabwean economy has not exhibited any significant structural changes between 1980, 2014 and 2020, and therefore, these results can be applied to the current period with appropriate qualification. This study is deliberately meant to be a narrow study of the impact of mining on economic growth and development. Future studies should expand the scope to an empirical investigation of all forms of mining linkages to give a complete picture of the place mining assumes in the economic development of Zimbabwe.

10. Acknowledgements

11. References

i. Afeku, C. & Debrah, A.A. (2020). Policy Convergence on Development Minerals in Africa: A Study of Ghana's Regulatory Frameworks. *The Extractive Industries and Society, 7(2)*, 488-496.
ii. African Union (2009). *African Mining Vision (AMV)*. Addis Ababa: African Union.
iii. Al-moneef, N. (2006). Forward linkages in the Petroleum Sector. *Journal of Resources Management, 16.*
iv. Aroca, P. (2001). Impacts and development in local economies based on mining: The case of Chilean II Region. *Resource Policy*, 27(2), 119-134
v. Aroca (n.d.). *Diversification and Development in Local Economies Based on Mining Sector: The Case of the Chilean II Region.* Retrieved on 16 July 2013 from http://r0.unctad.org/infocomm/diversification/cape/pdf/aroca.pdf.
vi. Auty, R.M (n.d.). *Maximizing the Positive Socio-Economic Impact of Mineral Extraction on Regional Development in Transition Economies: A Review of the Literature*.
vii. Chamber of Mines of Zimbabwe (2012). *Annual Statement*. Harare.
viii. Chamber of Mines of Zimbabwe (2013). 2013 Annual Report. Harare.
ix. Chamber of Mines of Zimbabwe (2013). *Unlocking Zimbabwe's Mineral Wealth to Maximize Socio-economic Development*. The World Bank sponsored workshop on mining in Zimbabwe, Nyanga, May 17, 2013.
x. Chiang, A.C. (1984). *Fundamental Methods of Mathematical Economics*. Third Edition. Auckland: McGraw-Hill International Editions, Economic Series, McGraw-Hill Book Company.
xi. Columbia Center on Sustainable Investment (CCSI) (2016). *Linkages to the Resource Sector: The Role of Companies, Government and International Development Cooperation*. GIZ. Retrieved on 03 August 2020 from http://ccsi.columbia.edu/files/2016/07/Linkages-to-the-resource-sector-GIZ-CCSI-2016.pdf.pdf.
xii. CSO (1986). *Quarterly Digest of Statistics*. December 1986, Harare.
xiii. CSO (1988). *The Input-Output Structure of the Economy of Zimbabwe 1980*. Harare.
xiv. Difference Between (2020). Difference Between Knowledge and Skill. Retrieved on 01 July 2020 from http://www.differencebetween.net/language/difference-between-knowledge-and-skill/.
xv. Econ & Bus Geog (2002). *I/O Multipliers*. Retrieved on 18 January 2014 from http://faculty.washington.edu/krumme/systems/multp.html.
xvi. Everret, R., Mlambo, L. & Makore, G. (2014). *Building Trust and Transparency in the Zimbabwe Mining Sector.* IBI International, Nathan Associates and USAID-SERA. Washington, D.C.

xvii.   Extractives Hub (2020a). Economic Linkages in the Extractives Sector. Retrieved on 01 July 2020 from https://www.extractiveshub.org/topic/view/id/47/chapterId/523.

xviii.   Extractives Hub (2020b). Economic Linkages in the Extractives Sector. Retrieved on 08 August 2020 from https://www.extraciveshub.org/topic/view/id/47/chapterId/523.

xix.   Franks, D.M. (2020). Reclaiming the Neglected Minerals of Development. *The Extractive Industries and Society, 7*, pp. 453-460.

xx.   Gocht, W.R., Zantop, H. & Eggert, R.G. (1988). *International Mineral Economics*. Berlin: Springer-Verlag.

xxi.   Godana, T. (1997). *Quantitative Methods Notes*. Orally delivered notes on the Master of Science Degree Programme in Economics, Economics Department, University of Zimbabwe.

xxii.   Hawkins, T. (2009). *The Mining Sector in Zimbabwe and its Potential Contribution to Recovery*. Comprehensive Economic Recovery in Zimbabwe, Working Paper Series. United Nations Development Programme. Retrieved on 22 December 2009 from http://www.undp.org.zw.

xxiii.   Eggert, R.G. (2002). Mining and Economic Sustainability: National Economies and Local Communities. *Mining, Minerals and Sustainable Development (MMSD)*.International Institute for Environment & Development IIED and World Business Council for Sustainable Development WBCSD. Retrieved on 04 August 2020 from https://pubs.iied.org/pdfs/G00952.pdf.

xxiv.   International Study Group Report on Africa's Mineral Regimes (2011).

xxv.   Jourdan, P., Chigumira, G., Kwesu, I., and Chipumho, E. (2012). *Mining Sector Policy Study*. Harare: Zimbabwe Economic Policy Analysis and Research Unit.

xxvi.   Lebdioui, A. (2020). Uncovering the High Value of Neglected Minerals: 'Development Minerals' as Inputs for Industrial Development in North Africa. *The Extractive Industries and Society, 7(2)*, pp.470-479.

xxvii.   Maleki, A. (2010). Leveraging oil and gas sector in industrialization and knowledge based economic development process: 'Linkage' approach to 'dual track' strategy in Algeria. *The 8th GLOBELICS International Conference* on 'Making Innovation Work for Society: Linking, Leveraging and Learning', 1-3 November 2010, University of Malaya, Kuala Lumpur, Malaysia. Retrieved on 5 September 2013 from http://umconference.um.edu.my/upload/43-1/papers/010%20AliMaleki_AmarSiAbdelhadi.pdf.

xxviii.   Manning, D.A.C & Theodoro, H.S. (2020). Enabling Food Security through Use of Local Rocks and Minerals. *The Extractive Industries and Society, 7(2)*, pp. 480-487.

xxix.   Mlambo, L. (2010a). Estimation of technical progress in Zimbabwe mining sector (1977-1997): An economic perspective. *Global Conference on Business and Finance Proceedings, 5(1)*, 271-282.

xxx.   Mlambo, L. (2010b). *Zimbabwe Geological Report*. Draft report prepared for the Raw Materials Group (Sweden).

xxxi.   Mlambo, L. (2016). *Extractives and Sustainable Development I: Minerals, Oil and Gas in Zimbabwe*. Friedrich-Ebert-Stiftung. Harare.

xxxii.   Mlambo, L. (2018a). *Extractives and Sustainable Development II: Minerals, Oil and Gas Sectors in Zimbabwe*. Friedrich-Ebert-Stiftung. Harare.

xxxiii.   Mlambo, L. (2018b). *The fiscal landscape for the Platinum Group Metals Sector in Zimbabwe: Comparison with other mining jurisdictions*. Consultancy report prepared for the Chamber of Mines of Zimbabwe.

xxxiv.   Mugandani, E.T. & Masiya, T.T. (2011). *Introduction to Basic Geology and Extraction of Metals*. Short Course in Mineral Identification and Metal Extraction Products Identification for MMCZ: Inspectorate & Monitoring Department, University of Zimbabwe, Harare.

xxxv.   Mugumbate, F. (2010). *Exploration Opportunities in Zimbabwe*. Zimbabwe Geological Survey. Retrieved on 17 February 2012 from http://zimminingindaba.com/uploads/2010%20Presentations/Indaba%202%20of%207/Mineral%20potential%20of%20Zimbabwe%20-%20Forbes%20Magumbate.pdf.

xxxvi.   Oyejide A.T. and Adewuji, A.O. (2011). *Enhancing linkages of oil and gas industry in the Nigerian Economy*. MMCP Discussion Paper.

xxxvii.   Piffaretti, N.F.(2013). *The Challenge of Mineral Wealth: Resource Endowment and Sustainable Development (Understanding Linkages)*. World Bank. May 17. Nyanga.

xxxviii.   Pissarenko, D. (2003). *Basics of Input-Output Analysis.* Retrieved from18 August 2014 from http://demetrix.sourceforge.net/resources/2003_02_20_ioAnalysis/ioAnalysis.pdf.

xxxix.   Platinum Producers Committee of the Chamber of Mines of Zimbabwe (2012*). Presentation to: The Permanent Secretary and Senior Officials (of) the Ministry of Mines and Minerals (sic) Development*. Presentation made at Holiday Inn, Harare, on 30 August, 2012.

xl.   Roussos, P. (1988). *Zimbabwe: An Introduction to the Economics of Transformation*. Harare: Baobab Books.

xli.   Rudawsky, O. (1986). Mineral Economics – Development and Management of Natural Resources. *Developments in Economic Geology, 20*. Amsterdam: Elsevier.

xlii.   Stilwell, L.C., Minnitt, R.C.A., Monson, T. D. & Kuhn, G. (2000). An Input-Output Analysis of the Impact of Mining on South African Economy. Resources Policy, Vol 26, Issue 1, pp.17-30. Elsevier. Retrieved on 03 August 2020 from sciencedirect.com.

xliii.   Torvik, R. (2009). Why do some resource-abundant countries succeed while others do not? *Oxford Review of Economic Policy, 25(2),* 241-256.

xliv.   UNCTAD (2010). *Creating local Linkages in the Mining sector*. UN Discussion Paper.

xlv.   UNECA (2011). *Optimizing Mineral-based Linkages.*

xlvi.   Valliers, A. (1993). Zimbabwe: Mineral Exploration and Investment Guide. *Mining Journal Research Services*, London.

xlvii.   Wolff, R. (n.d.). A Global Robustness Measure of Input-Output Projections from ESA and SNA Tables. *Fourteenth International Conference on Input-Output Techniques, October 10-15, Montreal, Canada.*

xlviii. World Bank (2014). Zimbabwe *Economic Policy Dialogue: Policy Notes for the New Government-2013*. Office of the Publisher. Washington, DC. Retrieved

xlix.   www.sfu.ca/~heaps/368/368IO.pdf, Retrieved on 18 August 2014.

l.   www.stat.go.jp/english/data/io/2005/pdf/ioe05005.pdf, Retrieved on 18 August 2014.

li.   Zimbabwe Environmental Law Association, ZELA (2012). *An Outline of the Mining Taxation Regime in Zimbabwe*. Harare: ZELA.

[i] Type I multipliers account for direct and indirect mining impacts on the various sectors and the economy as a whole, and abstract from induced effects of households' spending from their incomes.

[ii] Platinum Group Elements

[iii] That is, ore containing the elements platinum, palladium, rhodium and gold

[iv] www.stat.go.jp (n.d, p.83) calls this the production inducement coefficient of, in this case, the 1st sector.

[v] Type I = $(direct + indirect)/direct$. This is the same as equation (6) in a situation where we are considering a unit ($1) change in mining output

[vi] The question of what method can be used to effect the adjustment is a very important question.

[vii] This includes earnings, gross operating profit, taxes and imported inputs